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ABSTRACT

This paper describes a computerized environment for teaching the conceptual patterns of critical literacy. While the full implementation of the software covers both reading and writing, this paper covers only the writing aspects of R-WISE (Reading and Writing in a Supportive Environment). R-WISE consists of a suite of computerized "tools" to aid ninth-graders in learning the art of prose composition. The project is part of a 7-year Air Force effort--the Fundamental Skills Training project--to transition advanced computer-aided instruction to the public school sector. This paper gives an overview of the approach the tutor uses, its underpinnings in cognitive and textual theories, and the results of a pilot study. The three components of R-WISE mirror the widely accepted model for the composing process: Cubing (prewriting), Idea Board (Drafting), and Revision. Part of the instructional guidance comes from adaptive tutoring using traditional artificial intelligence (AI) formalisms, and part of the teaching comes from the powers of reification (or representing complex processes as manipulable objects on the computer screen). The tutoring environment includes: setting goals; visual algorithms; diagnosis and repair; adaptive advice; and just in time tutoring. Approximately 650 ninth-graders in a San Antonio, Texas high school were field tested during the academic year 1992-93. The difference in means on pre- and post-tests, represented by a 7% gain by the treatment group, was deemed significant. (Contains 10 references.) (MAS)

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R-WISE: A Computerized Environment for Tutoring Critical Literacy

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Abstract: This paper describes a computerized environment for teaching the conceptual patterns of critical literacy. While the full implementation of the software covers both reading and writing, this paper covers only the writing aspects of R-WISE (Reading and Writing in a Supportive Environment). The project is part of a seven-year Air Force effort -- the Fundamental Skills Training project -- to transition advanced computer-aided instruction to the public school sector. This paper gives an overview of the approach the tutor uses, its underpinnings in cognitive and textual theories, and the results of a pilot study completed in 1993.

Background and Purpose

The national attention focused on the "literacy crisis" addresses a significant and real problem in contemporary America -- the alarming increase in numbers of people who simply cannot read. However, deficiencies in composition are just as noteworthy. Most adolescent learners write only on a minimal level of acceptability. Furthermore, their inadequacy is not necessarily a result of poor spelling, vocabulary, grammar, verbal fluency, syntax, paragraphing, or other such production skills. Bereiter and Scardamalia call the form of writing practiced by inexperienced writers *knowledge telling* (1987). For these two noted researchers, *knowledge telling* is characterized by (1) a simple task execution involving only limited planning and minimal mental engagement, (2) production methods adapted from oral abilities, (3) organizational patterns based on free-association or simple narration, (4) development that contains large chunks of irrelevant information or elaborations based on simple descriptions, and (5) an egocentric perspective. The antithesis, *knowledge transformation*, as practiced by good writers, is characterized by (1) guided planning and situational diagnostics, (2) rich mental representations of text possibilities for a wide range of scenarios, and (3) a robust "executive control program" for allocating mental resources and for handling the tremendous cognitive load of verbal composition.

Computers and the Teaching of Writing

The notion of using computers to facilitate the teaching of writing has been around for quite some time (Bangert-Drowns, 1993). In general, one can see two broad trends in the early efforts: (1) research into whether or not word processing alters composing, and (2) various forms of parsers and natural language processing for detecting flaws in text (such as the many separate programs in the Writer's Workbench®). Both efforts have produced only limited results because both technologies -- at their roots -- are intended to enhance productivity rather than facilitate cognition. In short, they are just not the type of tool -- as

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delineated by Gavriel Salomon (1993) -- to produce a lasting gain in performance, *once the tool has been removed.*

R-WISE encourages students to practice composition in a computer-mediated environment, where the specially-designed software acts as a *procedural facilitator*. This term is used by Vygotsky (1978) to explain the cognitive mentoring and developmental dynamics that occur between master and apprentice and between peers during collaboration. Salomon (1988) and Zellermayer (1991), among others, uses the term to suggest that the computer can serve as a peripheral brain for the fledgling student and provide the scaffolding that allows the novice to practice the more robust problem-solving behaviors of an expert. R-WISE serves as a *cognition facilitator* for critical thinking by:

- Easing demands on short-term memory and helping to focus attention on strategically important aspects of writing;
- Guiding the inculcation and self-initiation of higher-order processes (metacognition) which the novice writer is unlikely to activate without prompting;
- Explicitly modeling strategic intellectual processes so that the fledgling student avoids what Collins & Gentner (1980) have termed "downsliding," or becoming increasingly entangled in lower and lower levels of mental actions, finally concentrating all mental energy on such things as spelling, grammar, and sentence construction to the exclusion of larger concerns in the process.

Software Components

R-WISE consists of a suite of computerized "tools" to aid ninth-graders in learning the art of prose composition. We selected the tools based on (1) their potential to represent components of the writing process as a visual algorithm and (2) their ability to model robust expert behaviors for the student. A simple model for the composing process that has gained wide acceptability in pedagogy depicts writing as having three central phases or stages: (1) Prewriting or invention, (2) Writing or drafting, and (3) Revision or editing. The three components showcased in this paper mirror this partitioning of the process.

- Cubing (Prewriting) -- Information is not knowledge, just as understanding the content of a piece of prose is not equivalent to understanding and using the concepts presented in a text. This tool -- based on a graphical representation of complex mental operations -- helps the student to draw inferences and to elaborate on the basic concepts being developed in a piece of emergent text.
- Idea Board (Drafting) -- This tool mediates a major cognitive shift in the writing process -- from the macro structures of thought to the micro structures of socially accepted, connected prose. Using a visual algorithm, the tool models robust, expert behaviors for writing a first draft. By foregrounding activities at appropriate times and relegating others to less prominence, the tool teaches the student to manage the cognitive load of composition.
- Revision -- This tool helps the student to "re-see" a completed draft. Editing, as fostered in this tool, refers to substantial changes, such as improving style, adding to or subtracting from the content, rearranging parts, or completely re-writing. These more global, deep-structured editing acts are associated with higher-order cognitive skills (e.g., discerning patterns in bodies of information, exercising judgment, analysis, synthesis).

Instructional Approach

R-WISE uses a hybrid paradigm for interactive instruction. Part of the guidance comes from adaptive tutoring using traditional AI formalisms and part of the teaching comes from the powers of reification (or representing complex processes as manipulable objects on the computer screen). Tools (1) accommodate deficiencies and thereby reduce frustration for a weak writer, (2) emulate some of the crucial functionality of paper copy, (3) enrich the environment and thereby sustain motivation, and (4) model robust behaviors. While each of the three tutors being considered concentrates on a specific cluster of skills, all three have a unified method for delivering this layered instruction and a canonical architecture for the software and the interfaces. Figure 1 guides the discussion for the next six subheadings.

Setting Goals: (Area 1 of Figure 1) Using a *knowledge-telling* approach, the novice writer views composition as if it were a straight-forward exercise in generating ideas through association. For the expert, however, having an explicit, stable set of goals fosters a kind of filtering activity that focuses the mental task from the outset.

Each of the three cognitive tools handles this concretizing of goals in a slightly different manner. In *Cubing*, the tool selects from a collection of 9 possible readers and 9 possible reasons to write, (e.g., write a persuasive piece for a reader who is an expert in the subject matter). The student is then given this combination as a rhetorical situation. *Idea Board* asks the student to pick from a list the most applicable response to each of four questions that identify the purpose, the audience, the text form, and anticipated difficulties. *Revision* asks the student to set "sliders" to indicate three dimensions of the reader and three dimensions of the writer.

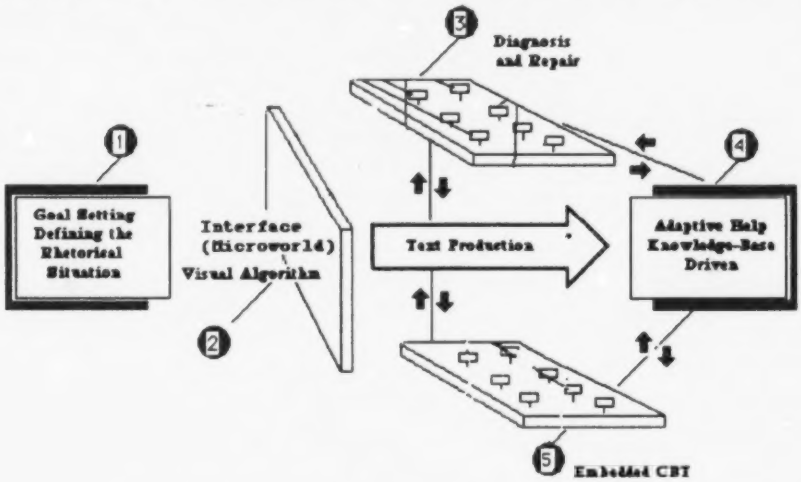

Figure 1: System overview of hybrid tutoring capabilities

Not only does this exercise help the novice student focus on an area where she is weak, this preliminary work "sets" the parameters of the adaptive tutor. Each writing environment now has a "frame" or backplane of conditions against which further actions can be evaluated during the remainder of the session on the tool. (If the student changes goals, the frame is also updated.) Table A gives the number of combinations (or rhetorical situations) tracked by each of the tools. Clearly, the repertoire is rich, and becomes even richer as these preliminary combinations are conjoined with additional data points drawn from the student's subsequent activities as the writing progresses.

Table A

Tracking Combinations in the Frame

TOOL	CONDITIONS	COMBINATIONS
Cubing	Reader Profiles (9) Aims or Purposes (9)	81
Idea Board	Purpose (5) Audience (6) Form (6) Difficulties (7)	1,260
Revision	Reader's Age (3) Reader's Knowledge (3) Reader's Attitude (3) Writer's Distance (3) Writer's Tone (3) Writer's Purpose (3)	729

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Visual Algorithms: (Area 2 of Figure 1) The second way in which R-WISE teaches is to reify complex and potentially covert mental operations. Where possible, the interfaces of R-WISE represent visual organizers for specific intellectual processes. As explained by J. H. Clarke (1991, pp. 526-7), ". . . [f]rom the standpoint of cognitive theory, graphic frames mimic aspects of semantic memory structures or schemata, that learning theorists believe organize the mind." For example, "Idea Map," an early workspace in Idea Board that encourages structured brainstorming by presenting the student with a visualization of mental manipulations. Given the premise that most of the clients for R-WISE probably have learning preferences that are concrete/visual rather than abstract/language, we provide "objects" for obscure mental actions. Similar to "webbing" -- a paper-and-pencil technique used in the writing classroom -- this thinking frame prods the student to cluster ideas into proto-paragraphs. Working with the "Idea Map" helps the student to recognize and to take control of the intellectual processes foundational to composing.

Diagnosis and Repair: (Area 3 of Figure 1) Writing is a complex, multi-dimensional activity analogous to a contingency management problem. Only in working through candidate solutions does the nature of the problem become fixed, or even definable. Rather than working in a linear fashion through the model of PLAN - PREWRITE - DRAFT - EDIT, good writers use an opportunistic approach. They constantly measure the emerging text against a set of expectations, while at the same time recognizing and capitalizing on serendipitous gains, weaving these "discovered" possibilities into a new rendition of the overall plan and product.

Unfortunately, text production strategies for novice writers are frail and one-dimensional; such impoverished capabilities do not lend themselves to interruptions or re-assessments. As evidenced by Bereiter and Scardamalia's research into the writing process for novices, little evidence can be found that weak writers can participate in self-cueing or self-monitoring activities while engaged in a production of text (1987). In fact, the very act of breaking out of their one-dimensional, stream-of-consciousness mode jeopardizes the continued production of text. Diagnosis-and-Repair is an evaluation loop that partners with the student to reduce the cognitive load and that encourages the student to enter into an assessment episode. This loop -- essentially modeled after Bereiter and Scardamalia's well-researched CDO (COMPARE, DIAGNOSE, OPERATE) sequence (1987) -- takes a very sophisticated, open-ended problem and pares it down to a manageable set of options for the inexperienced writer.

Clearly, the lists of options are a form of embedded instruction, and the student probably will come away from extended exposure to any of the three tutors with better content knowledge about what can go wrong at various stages of composition. However, we feel that the more important lesson the student learns is an enriched self-regulatory capacity so that she can move out of the text production mode into a higher-level cognitive activity without disrupting the whole composing process. This ability to suspend operations on one level and to focus mental energies on another is characteristic of the experienced writer (Hayes and Flower, 1980).

Adaptive Advice: (Area 4 in Figure 1) In the metacognitive stage (diagnosis and repair), the machine partners with the student to develop the sensitivity and awareness necessary to know what is wrong with a prose performance and how to improve the result. Yet, because the diagnostic is performed by the student, there is a potential for a mis-judgment. Additionally, if the system is to serve as an intelligent "guide" or "coach," the tool should have a feedback loop to indicate the "reasonableness" of the course of action the student is pursuing, baselined against some known set of criteria.

Adaptive advice adjusts its statements based on an "intelligent" assessment of the situation -- meaning that the software compares the manipulation the student is working on with the conditions of the frame and determines how "correct" these actions are given the circumstances. The resultant prompts help the student to learn the more subtle aspects of adaptation to audience and purpose. They also help the student to stay on the right track and avoid the frustration of writing text that is later deemed to be inadequate to the task. *Cubing*, *Idea Board*, and *Revision* contain advice that is germane to the focus of the tool. For example, *Cubing* -- whose domain is prewriting or the invention phase of writing -- prods the student to generate ideas. *Revision*, on the other hand, contains advice to aid in the assessment of such things as coherence, introductory and concluding paragraphs, whole-paper arrangement, paragraph structures, and effectiveness of individual sentences.

For all the intelligent tools, adaptive help is generated through a kind of triangulation, based on the rhetorical situation (frame) and the moves made by the student in the microworld or visual workspace. Monitoring the combination of rhetorical situation and place in the writing process creates a rich

representation for accessing instructional statements. Table B shows the number of instructional situations captured in each tool. Because of the large numbers, in the current version of R-WISE, we have implemented a pruning algorithm that weighs the various elements going into the instructional situation and generates a manageable set of instructional statements. For example, the student (having written a topic sentence for a paragraph of factual detail intended for an audience at a distance from the writer, younger than the writer, and less knowledgeable than the writer) might be prompted to consider whether or not the advanced organizer is adequate for the purpose and the audience.

Table B
Generating Adaptive Help

TOOL	FRAME COMBINATIONS	DIAGNOSTIC CHOICES	INSTRUCTIONAL SITUATIONS	ADVICE STATEMENTS
Cubing	81	18	1,458	72
Idea Board	1260	18	22,680	50
Revision	729	27	19,683	153

Just in Time Tutoring: (Area 5 in Figure 1) While designing R-WISE, we carefully planned how to integrate the tutor into a year-long ninth-grade curriculum. As currently fielded, the tutor takes up about 20-25% of the course. The production skills necessary for writing (e.g., topic sentences, paragraph patterns, conclusions and introductions, and other rhetoric fundamentals) are taught in the classroom, not on the computer. This is a deliberate decision. To act as an accelerator, the computer has to support the *process* of literacy. Interrupting the process to teach the enabling skills (1) mixes levels, styles, and purposes of instruction, (2) creates breaks in the train of thought from which the student cannot recover, and (3) results in a fairly unexciting electronic workbook.

While production skills and metacognitive skills are not interchangeable, they are correlated in that they must occur simultaneously in expert behaviors. After diagnosing a problem and getting a repair, the student may still be at a loss as to what to do. Recognizing that students may need reminders of materials covered in class, we have embedded a CBT component in R-WISE which provides "hints" upon request. This instruction (similar to a high-end form of context-sensitive help) is analogous to a *job aid* in that it gives a synoptic overview of concepts presented in class. Its purpose is to serve as a reminder or a refocusing prompt for the student rather than a full-blown instructional component. All three tools have a just-in-time-tutoring (JITT) module for each diagnostic choice they present. Each unit is terse and highly visual, representing fundamentals of composition with conceptual maps and pseudo-animations.

Pilot Study and Future Plans

A pilot version of R-WISE was field-tested during academic year 1992-1993. A San Antonio, Texas, high school with a population of approximately 650 ninth-graders used various components of the system over a nine-month period. In working with this Beta-test site, we were interested in a variety of research questions, including issues of design and user acceptance. We used several instruments to measure learning outcome, but only the results of the writing sample are presented here.

A second high school, within the same district and demographically similar to our pilot site, was selected as a control. Two equivalent writing prompts were devised, and one was given in January as a pre-test; the other was given in May as a post-test. We devised a rubric for holistically scoring the papers on a 1 to 6 scale and then had the approximately 2,200 samples professionally evaluated. The standard procedure of having two readers examine each paper was used. Inter-rater reliability was .79. The differences in means on pre-test and post-test for both control and treatment were deemed statistically significant using t-tests and are given in Figure 2. We are encouraged by the approximately 7% gain accomplished by the treatment group, but are cautious in our interpretations given that the software was in a beta version during

the pilot study. A more finished version of R-WISE is now being used by nine test sites in five different states. We hope to get even more of an effect from this production version of the software.

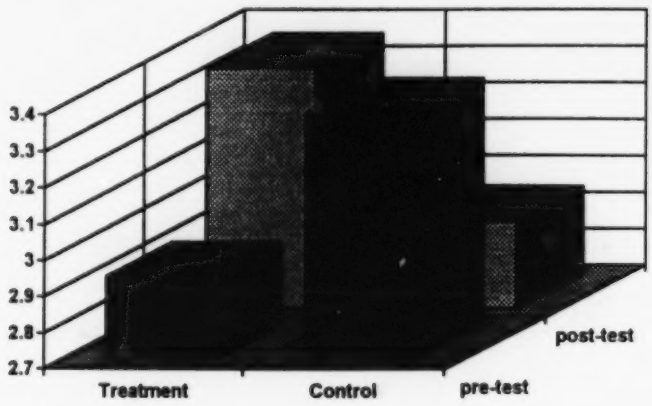

Figure 2: Mean scores for control and treatment on pre and post tests

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